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Neuropsychometric Test in Royal Netherlands Navy Mine-Clearance Divers

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Background: In recent years, there has been growing concern within the diving community that divers may be suffering long-term neurological damage [1-4]. Neurological changes may exist either as clinical manifestations or as silent asymptomatic abnormalities only demonstrated by neurological and neuropsychological techniques [5]. The aim of this study was to investigate possible neuropsychometric effects in Netherlands Navy mine-clearance divers without any previous neurological decompression sickness.

Methods: Forty-three Navy mine-clearance divers were selected based on a career of at least 15 years of military diving. The average age of the divers was 42 (range 37-50) years. Their mean diving experience was 1767 (range 734 - 2800) dives (Table 1).

Table 1 Data on exposure for the Navy divers

	Divers (N=43)		
	Mean	SD	Range
Exposure			
– Years of diving	18.7	7.1	15-29
– Number of dives last year (<30 meter)	44.0	45.2	4-130
– Number of dives last year (>30 meter)	24.4	19.3	1-75
– Total dives to 30 meter [a]	1272	699	300-3000
– Total dives deeper than 30 meter [b]	495	334	20-1500
– Mean divetime (min) to 30 meter [c]	50.5	15.0	18-100
– Mean divetime (min) deeper than 30 meter [d]	45.2	25.0	8-80
– Dive index [a*c/60+b*d/60] (hours)	1464	839	177-4000

A computerized neuropsychological test battery, the Neurobehavioral Evaluation System (NES2) was applied [6]. The battery consists of tests in the domains of Attention (Simple Reaction Time Test, Switching Attention Test), Motor performance (Finger Tapping Test, Hand-Eye Coordination Test), Learning and memory (Verbal Memory Test, Digit Memory Span Test-Forwards/Backwards), Perceptual coding (Symbol-Digit Substitution Test) and Verbal ability (Vocabulary Test) (Table 2).

Table 2 Computer Administered Neurobehavioral Tests

Test	**Abbreviation**	**Function**
Vocabulary	VT	Verbal ability
Finger Tapping Test	FTT	Motor performance
Simple Reaction Time Test	SRTT	Attention
Verbal Memory Test (1)	VMT-1	Learning/memory
Switching Attention Test	SWAT	Attention
Symbol-Digit Substitution Test	SDST	Perceptual coding
Hand-Eye Coordination Test	HECT	Motor performance
Verbal Memory Test (2)	VMT-2	Learning/memory
Digit Memory Span Test (F/B)	DMST-F/B	Learning/memory

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In addition, questionnaires for neurotoxic symptoms (Neurotoxic Symtom Checklist-60, NCS-60) and mood states (Profile of Mood Scales, POMS) were used. The tests in the domains were evaluated using Hotellings T^2 test, individual tests were analysed with T-tests or Mann Whitney tests were appropriate. A group of Navy corpsmen (n=68) matched for age, education and vocabulary score was recruited to serve as the control population (Table 3).

Table 3 Demograhics

	Divers	Control group
– **Number** of persons	43	68
Gender		
– All males	43	68
Age		
– Mean (years)	42.2	42.3
– SD	4.3	3.5
– Range	37-50	36-50
Education		
– Level (Groninger Scale)	4.3	4.2
– SD	1.1	0.9
– Range	2-6	3-7
– School years (N=)	11.6	11.0
– SD	3.3	2.0
– Range	8-23	8-18
Vocabulary score		
– Correct (N=)	13.1	13.2
– SD	2.5	3.1

Results: The Navy clearance divers showed no abnormal neuropsychometric test results compared to the Navy control population. The divers had significantly better scores for the DMST and FTT ($p<0.05$) (Table 4).
There were no differences in NSC-60 and POMS scores between the divers and control group (data not shown). Subjects of both groups had normal values compared with the reference values for the test. No relationship was found between the effect parameters and diving exposure in our naval diving population.

Discussion: In this study on mine-clearance divers we found no clear evidence of neuropsychometric deficits due to extensive diving exposure. This is in contrast to results of other studies, although most of these latter studies involved saturation divers [7-9]. In the Royal Netherlands Navy, the extensive initial medical and psychological screening, the yearly medical control and the use of conservative decompression procedures are the factors which most likely contribute to the healthy neuropsychometric status of our divers.

Table 4 Results of neuropsychometric performance

	Divers (n=43)		Control group (n=68)		t-test	
	Mean	SD	Mean	SD	t-value	p-value
Attention/speed					8.73[a]	0.32
Simple Reaction Time Test						
– Latency (ms)	217.3	21.8	220.8	34.4	-0.59	0.55
Color Word Vigilance Test						
– Latency (ms)	588.1	60.3	594.6	66.8	-0.52	0.60
– # false positive	0.56	0.73	1.12	1.57	1152[b]	**0.043**[c]
– # omissions	0.49	0.67	0.76	1.04	1320[b]	0.33
Switching Attention Test						
– latency "side" (ms)	253.5	38.0	259.0	37.4	-0.75	0.45
– latency "direction" (ms)	414.1	65.8	411.8	57.9	0.19	0,85
– latency "switching" (ms)	617.1	192.6	638.0	164.3	-0.61	0,54
Perceptual coding					-0.16	0.87
Symbol-Digit Substitution Test						
– latency "symbol- figure" (sec)	2.57	0.33	2.58	0.30	-0.16	0.87
Learning/memory					16.7[a]	**0.036**[c]
Verbal Memory Test						
– # correct trial 1/5	43.6	10.7	43.4	9.8	0.09	0.93
– # correct "short delay free recall"	8.7	3.2	8.6	3.2	0.22	0.83
– # correct "long delay free recall"	9.1	3.0	9.4	2.9	-0.49	0.63
– # correct recognition– list	14.3	1.6	13.8	2.1	1.31	0.19
– semantic clustering	2.1	0.9	2.1	0.7	-0.05	0.96
Digit Memory Span Test						
– mean span length forwards	6.65	0.95	6.18	0.92	2.63	**0.0098**[c]
– mean span length backwards	5.93	1.12	5.42	1.10	2.39	**0.019**[c]
Motor performance					11.02[a]	0.068
Hand-Eye Coordination Test						
– mean absolute error "sine wave" (pixels)	1.61	0.26	1.63	0.26	-0.39	0.69
– mean absolute error "tooth of saw" (pixels)	1.86	0.21	1.86	0.24	0.03	0.98
Finger Tapping Test						
– # taps dominant hand	168.9	30.7	153.6	28.1	2.69	**0.0082**[c]
– # taps non-dominant hand	161.6	29.2	146.3	21.7	2.97	**0.0041**[c]
– # taps alternative	214.6	60.2	200.0	49.8	1.39	0.17

a: Hotelling T^2 test b: Mann- Whitney test c: significantly better score in divers group compared with control group

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